

1 A SOFTWARE BASED INTERNET PROTOCOL ADDRESS SELECTION METHOD
2 AND SYSTEM

3
4 BACKGROUND OF THE INVENTION

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6 1. Field of the Invention

7 The present invention relates generally to methods for IP address selection, and
8 more particularly to a software based internet protocol address selection method.

9 2. Discussion of Background Art

10 Universal Resource Locator (URL) Domain Name System (DNS) entries are
11 uniquely associated with Internet Protocol (IP) addresses and help route communications
12 traffic between clients and servers within the World Wide Web.

13 When a company's servers share a single location, IP address routers simply route
14 all traffic to this single location. However, as more and more companies establish a multi-
15 regional or global presence, mirrored servers hosting such companies' web sites may be
16 geographically distributed over several locations in order to ensure sufficiently short
17 response times to client requests. As a result, Web site managers are confronted with a
18 problem of which server will provide the best possible response time and performance for
19 the client.

20 There are several current approaches to this problem. The simplest is to require
21 that the client select a server from a list provided on the company's main Web site. Other
22 approaches use specialized hardware to perform various measurements in order to direct
23 clients to the best Web server. These types of solutions however typically involve the
24 installation of very expensive hardware and require additional layers of IT support. Such

1 hardware can thus be cost prohibitive to some smaller companies. Cisco System's
2 Distributed Director http://www.cisco.com/warp/public/cc/pd/cxsr/dd/tech/dd_wp.htm is
3 an example of one such hardware based solution. Other vendors, such as ArrowPoint and
4 Foundry are also pursuing a variety of hardware based approaches to solve this domain
5 name resolution problem.

6 In response to the concerns discussed above, what is needed is a system and
7 method for internet protocol address selection that overcomes the problems of the prior
8 art.

9

SUMMARY OF THE INVENTION

The present invention is a method and system for software based internet protocol (IP) address selection. The method includes steps of assigning a single domain name to a set of server IP addresses, receiving a request for the domain name from a client IP address, retrieving a set of IP routes linking the server IP addresses and the client IP address, and selecting an IP route from the set of routes which meets predetermined criteria.

In other aspects of the invention, the method may transmit an IP address from the set of server IP addresses which corresponds to the selected IP route or retrieve the IP routes from routers using BGP, SNMP (MIB retrieval), or Telnet protocols and store the IP routes in cache and IP routes databases. Alternate embodiments may also select a best IP route between the client and server based on a shortest AS path, a lowest origin type, a lowest MED, a default IP address or a hierarchy of some or all of these criteria. A enhanced address resource record data-structure for supporting the present invention may include domain name, list of corresponding servers and routers, router retrieval parameters, default client/server IP route, and timeout fields.

The system includes a set of servers, having a single domain name, a client computer, a set of routers, coupled to the servers and the client computer, for storing IP routes between the servers and the client; and a domain name system server, coupled to the routers, for selecting one of the IP routes which meets predetermined criteria.

The system may also include a cache database, coupled to the domain name system server, for storing previously selected IP routes and an IP routes database, coupled to the domain name system server, for storing all of the IP routes.

1 The system and method of the present invention are particularly advantageous over
2 the prior art because of a lower cost and a simpler design associated with implementing IP
3 route selection using the present invention's software instead of hardware. The present
4 invention thus is able to meet the needs of many companies that are unable to afford
5 hardware-based systems.

6 These and other aspects of the invention will be recognized by those skilled in the
7 art upon review of the detailed description, drawings, and claims set forth below.

8

BRIEF DESCRIPTION OF THE DRAWINGS

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3 Figure 1 is a dataflow diagram for software based internet protocol address
4 selection within a Domain Name System (DNS) server;

5 Figure 2 is a data structure of an enhanced address resource record;

6 Figure 3 is a dataflow diagram of an initialization process;

7 Figure 4 is a dataflow diagram of an BGP IP Routes retrieval process within the
8 initialization process;

9 Figure 5 is a dataflow diagram of an MIB IP Routes retrieval process within the
10 initialization process;

11 Figure 6 is a dataflow diagram of a Telnet IP Routes retrieval process within the
12 initialization process;

13 Figure 7 is a dataflow diagram of a best client/server IP Route selection process;

14 Figure 8 is a dataflow diagram of an MIB IP Routes retrieval subroutine within the
15 best route selection process; and

16 Figure 9 is a dataflow diagram of an Telnet IP Routes retrieval subroutine within
17 the best route selection process.

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1 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

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3 Figure 1 is a dataflow diagram 100 for software based internet protocol address
4 selection within a Domain Name System (DNS) server 102. The DNS server 102 is
5 coupled to a network along with a first corporate server 106 router 108 pair, a second
6 corporate server 110 router 112 pair, and a client computer 114. The corporate servers
7 106 and 110 both have a same corporate domain name (e.g. corporation@corp.com) but
8 have different Internet Protocol (IP) addresses. The corporate servers 106 and 110 are
9 preferably mirrored and located at different geographic locations. The DNS server 102
10 contains a modified bind-code for downloading IP route information from the routers 108,
11 112 and selecting a best client/server IP route for connecting the client 114 requesting the
12 corporate domain name to one of the corporate servers 106, 110. An IP route is defined
13 by at least two IP addresses. Client/server IP routes are defined between the client's 114
14 IP address and each of the server's 106, 110 IP addresses. Those skilled in the art
15 recognize that in actual operable systems incorporating the present invention, hundreds, if
16 not thousands of client computers, and tens of servers and routers may be connected to
17 the network 104. As such, the DNS server 102 will select a best client/server IP route for
18 connecting each client with one of the servers and transmit a server IP address
19 corresponding to the best route to the client 114.

20

1 Figure 2 is a data structure 200 of an enhanced address resource ("A") record 202
2 generated by the modified bind-code of the DNS server 102. The "A" record 202
3 includes: a domain name 202 field for storing the corporate server's 106,110 common
4 domain name; a list of corresponding servers and routers 204 field for identifying servers
5 and routers assigned to the domain name 202; a route retrieval parameters 208 field
6 specifying how IP routes are to be downloaded from the routers 108, 112, a default best
7 client/server IP address 210 field containing an IP address for the client 114 to use should
8 the selection process for the best client/server IP route be indeterminate; a cache timeouts
9 field 212; and an IP routes timeouts field 214, for respectively keeping cache and IP route
10 information fresh.

11 The router retrieval protocol 208 field is set to either Border Gateway Protocol
12 (BGP), Management Information Base (MIB), or Telnet during configuration of the
13 network 104 and the DNS server 102. One protocol 208 is used for all routers 108, 112.
14

15 Figure 3 is a dataflow diagram 300 of an initialization process 302. All steps are
16 effected by software within the DNS server 102 unless otherwise noted. Initialization 302
17 begins in step 304 where the "A" record 202 is generated using a network bind
18 configuration file 306 and saved in an "A" record database 308. In step 310, a cache
19 database 312, for storing a set of previously selected best client/server IP route entries, is
20 initialized. Caching improves IP route selection speed and efficiency in response to
21 repeated communications from a same client or from a same client network address range.
22 An IP route database 314, containing all possible client/server IP routes, is initialized in
23 step 316.

1 In step 318, if a protocol within the router retrieval parameters 208 is set to BGP,
2 a BGP IP route retrieval routine is initiated in step 320, after which the initialization
3 process 302 ends. The BGP IP route retrieval routine is described with reference to
4 Figure 4. In step 322, the IP routes database timeout 214 in the enhanced "A" record 202
5 is accessed and if the timeout is set to zero, so as to force dynamic route retrieval, the
6 initialization process 302 ends. In step 324, if the protocol within the router retrieval
7 parameters 208 is set to MIB, a MIB IP route retrieval routine is initiated in step 326,
8 after which the initialization process 302 ends. The MIB IP route retrieval routine is
9 described with reference to Figure 5. Otherwise, the protocol within the router retrieval
10 parameters 208 is Telnet, and a Telnet IP route retrieval routine is initiated in step 328,
11 after which the initialization process 302 ends. The Telnet IP route retrieval routine is
12 described with reference to Figure 6.
13

1 Figure 4 is a dataflow diagram 400 of the BGP IP Route retrieval process 402
2 within the initialization process 302. The process 402 begins in step 404, where BGP
3 specific information is accessed from the router retrieval parameters 208 in the enhanced
4 “A” records 202 stored in the “A” record database 308. In step 406, a BGP session is
5 established with the routers 108, 112. BGP code is incorporated into the DNS server’s
6 102 software so that the DNS server 102 can directly peer with the routers. Thus the IP
7 routes database 314 can be updated real time. Next, in step 408, a BGP routing table is
8 downloaded from the routers 108, 112. The IP route database 314 is updated, in step
9 410. In step 412, the process 402 waits for a BGP protocol update signal or a termination
10 signal. If, in step 414, the termination signal is not received, the process 402 returns to
11 step 408, else the process 402 ends. As discussed with reference to Figure 1, those skilled
12 in the art will know that the present invention works equally well with many more than
13 just the one client and two servers and routers discussed herein.

15 Figure 5 is a dataflow diagram 500 of the MIB IP Routes retrieval process 502
16 within the initialization process 302. The process 502 begins in step 504, where MIB
17 specific information is accessed from the router retrieval parameters 208 in the enhanced
18 “A” records 202 stored in the “A” record database 308. In step 506, a Simple Network
19 Management Protocol (SNMP) session is established with and routing tables are
20 downloaded from the routers 108, 112. The process 502 uses network management
21 protocols to retrieve IP routes from a router’s management information base. The IP
22 route database 314 is updated, in step 508. In step 510, the process 502 waits for the IP
23 route database timeout to zero or a termination signal. If, in step 512, the termination
24 signal is not received, the process 502 returns to step 506, else the process 502 ends.

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2 Figure 6 is a dataflow diagram 600 of the Telnet IP Routes retrieval process 602
3 within the initialization process 302. The process 602 begins in step 604, where Telnet
4 specific information is accessed from the router retrieval parameters 208 in the enhanced
5 “A” records 202 stored in the “A” record database 308. In step 606, a Telnet session is
6 established with and routing tables are downloaded from the routers 108, 112. The
7 routing table information is updated periodically to keep the IP routes database 314
8 current. The IP route database 314 is updated, in step 608. In step 610, the process 602
9 waits for the IP route database timeout to zero or a termination signal. If, in step 612, the
10 termination signal is not received, the process 602 returns to step 606, else the process
11 602 ends.

12

13 Figure 7 is a dataflow diagram 700 of a best client/server IP Route selection
14 process 702. The process 702 begins in step 704 where in response to a domain name
15 request from the client 114, the DNS server 102 checks the cache database 312 for a
16 previously cached best client/server IP route entry between the client 114 and one of the
17 domain name servers 106, 110. In step 706, if the best client/server IP route cache entry
18 exists, the cache timeouts 212 are accessed. In step 708, if the cache entry has not timed
19 out, the process 702 proceeds to step 710. In step 710, the best client/server IP route
20 cache entry is retrieved from the cache database 312 and a server IP address
21 corresponding to the best route is transmitted to the client 114 in step 711. After step
22 711, the process 702 ends. In step 708, if the best client/server IP route cache entry has
23 timed out, the process proceeds to step 714. In step 712, the cache entry is removed from
24 the cache database 312.

1 Next, in step 714, the IP routes database timeout 214 is accessed. If the IP routes
2 database 314 has a non-zero timeout value, the process proceeds to step 716 where the
3 DNS server 102 retrieves all Client/Server IP Routes from the IP routes database 314. In
4 step 716, the DNS server 102 selects a best client/server IP route for the client 114 from
5 all of the client/server IP routes stored in the IP routes database 314.

6 The DNS server 102 sets the best client/server IP route equal to the IP route
7 having a shortest Autonomous System (AS) path. The AS path is a BGP protocol
8 attribute containing a sequence of autonomous system numbers which a route has
9 traversed to reach a destination. If the AS path for all client/server IP routes is equivalent,
10 the DNS server 102 instead selects the client/server IP route with a lowest origin type.
11 Origin type is a BGP protocol attribute indicating an origin of a routing update
12 with respect to an autonomous system that originated it. If the origin type for all
13 client/server IP routes is equivalent, the DNS server 102 instead selects the client/server
14 IP route with a lowest Multi_Exit_Disc (MED). MED is a BGP protocol attribute that
15 describes an external metric of a route. If the MED for all client/server IP routes is
16 equivalent, the DNS server 102 instead selects the default best client/server IP address 210
17 which is retrieved from the enhanced "A" record 202. Those skilled in the art recognize
18 that other best IP route selection methods are possible. In step 720, the DNS server 102
19 caches the best client/server IP route in the cache database 312 and the process 702
20 proceeds to step 711, which has been discussed above.

21 In step 714, if the IP routes database 314 has a zero timeout value, the process
22 proceeds to step 722. In step 722, the DNS server 102 accesses the protocol specified
23 within the router retrieval parameters 208. If the protocol is set to BGP, then the IP

1 routes database 314 will be updated continuously, and the process proceeds to step 716.
2 Step 716 is discussed above. Else, the process proceeds to step 724. In step 724, the
3 DNS server 102 accesses the protocol specified within the router retrieval parameters
4 208. If the protocol is set to MIB, the process proceeds to step 726. In step 726, a MIB
5 IP routes retrieval subroutine is executed, as described with reference to Figure 8. After
6 step 726, the process proceeds to step 720 discussed above. If the protocol was not set to
7 MIB, the protocol defaults to Telnet and the process 702 proceeds to step 728. In step
8 728, a Telnet IP routes retrieval subroutine is executed, as described with reference to
9 Figure 9. After step 728, the process proceeds to step 720 discussed above.
10

1 Figure 8 is a dataflow diagram 800 of an MIB IP Routes retrieval subroutine 802
2 within the best route selection process 702. The process 802 begins in step 804, where
3 SNMP (MIB retrieval) information is accessed from the router retrieval parameters 208.
4 In step 806, an SNMP session is established with the routers 108, 112, and routing tables
5 are downloaded real-time from a MIB database on the routers. A best client/server IP
6 route is selected from all client/server IP routes downloaded within the routing tables in
7 step 808. The best IP route is selected using the steps discussed with reference to step
8 718 in Figure 7, except that the IP routes in the IP routes database 314 are not accessed.
9 After step 808, the process 802 ends.

10

11 Figure 9 is a dataflow diagram 900 of an Telnet IP Routes retrieval subroutine 902
12 within the best route selection process. The process 902 begins in step 904, where Telnet
13 information is accessed from the router retrieval parameters 208. In step 906, a Telnet
14 session is established with the routers 108, 112 and routing tables are downloaded real-
15 time using the Telnet protocol. A best client/server IP route is selected from all
16 client/server IP routes downloaded within the routing tables in step 908. The best IP
17 route is selected using the steps discussed with reference to step 718 in Figure 7, except
18 that the IP routes in the IP routes database 314 are not accessed. After step 908, the
19 process 902 ends.

20

21 While one or more embodiments of the present invention have been described,
22 those skilled in the art will recognize that various modifications may be made. Variations
23 upon and modifications to these embodiments are provided by the present invention,
24 which is limited only by the following claims.

1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000 16000 17000 18000 19000 20000 21000 22000 23000 24000 25000 26000 27000 28000 29000 30000 31000 32000 33000 34000 35000 36000 37000 38000 39000 40000 41000 42000 43000 44000 45000 46000 47000 48000 49000 50000 51000 52000 53000 54000 55000 56000 57000 58000 59000 60000 61000 62000 63000 64000 65000 66000 67000 68000 69000 70000 71000 72000 73000 74000 75000 76000 77000 78000 79000 80000 81000 82000 83000 84000 85000 86000 87000 88000 89000 90000 91000 92000 93000 94000 95000 96000 97000 98000 99000 100000